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[Title of Invention] Optical Fiber Drawing Method and Drawing Furnace

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[Title of Invention] Optical Fiber Drawing Method and Drawing Furnace

[Claims]

[Claim 1] An optical fiber drawing method in which an optical fiber preform is supplied from an upper chamber into a furnace core tube, and while heating the upper portion of said upper chamber, the lower end of said optical fiber preform is softened with heat to allow optical fiber to be drawn;

characterized by

in the case where the upper end of said optical fiber preform is positioned at a heating area of the upper portion of said upper chamber, a step of facilitating heat dissipation from said upper portion without heating the upper portion of said upper chamber.

[Claim 2] An optical fiber drawing method in which an optical fiber preform is supplied from an upper chamber into a furnace core tube, and while heating the upper portion of said upper chamber, the lower end of said optical fiber preform is softened with heat to allow optical fiber to be drawn;

characterized by

in the case where the upper end of said optical fiber preform is positioned at a heating area of the upper portion of said upper chamber, a step of facilitating heat dissipation without heating the portion of said upper chamber facing the upper end of said optical fiber preform.

[Claim 3] The optical fiber drawing method according to Claim 1 or 2, wherein said step of facilitating said heat dissipation comprises

a step of distancing a heat source for heating the upper portion of said upper chamber from the upper portion of said upper chamber.

[Claim 4] The optical fiber drawing method according to any one of Claims 1-3, wherein the step of facilitating said heat dissipation comprises the use of cooling fluid.

[Claim 5] The optical fiber drawing method according to Claim 4, characterized in that said cooling fluid comprises air.

[Claim 6] The optical fiber drawing method according to Claim 4, characterized in that said cooling fluid compeises water.

[Claim 7] An optical fiber drawing furnace in which is provided a furnace core tube, which supplies an optical fiber preform; a main heater, which surrounds this furnace core tube; and a preform holding cylinder, which holds said optical fiber preform and is connected to the upper end of said furnace core tube;

characterized by

an auxiliary heater, which surrounds the upper portion of said preform holding cylinder; and

heater moving means, which moves the auxiliary heater between a heating position touching or near said preform holding cylinder and a heat dissipating position distant from said preform holding cylinder.

[Claim 8] The optical fiber drawing furnace according to Claim 7, characterized in that said auxiliary heater comprises a heat generating body and a heat insulator surrounding the heat generating body, and said heater moving means moving only said heat insulator between said heating position and said heat dissipating position.

[Claim 9] The optical fiber drawing furnace according to Claim 7 or 8, characterized by

at least one temperature sensor, which detects the temperature of said preform holding cylinder; and

control means, which control the operation of said auxiliary heater and said heater moving means based on the detection signal from this temperature sensor.

[Claim 10] The optical fiber drawing furnace according to any one of Claims 7-9, characterized by said auxiliary heater and said heater moving means in multiple stages along the length of said preform holding cylinder.

[Claim 11] An optical fiber drawing furnace in which is provided a furnace core tube, which supplies an optical fiber preform; a main heater, which surrounds this furnace core tube; and a preform holding cylinder, which holds said optical fiber preform and is connected to the upper end of said furnace core tube;

said optical fiber drawing furnace being characterized by comprising

an auxiliary heater, which surrounds the upper portion of said preform holding cylinder; and

cooling means, which cool the upper portion of said preform holding cylinder.

[Claim 12] The optical fiber drawing furnace according to Claim 11, characterized by a clearance formed between said preform holding cylinder and said auxiliary heater and by an airtight, annular, heat insulating wall provided surrounding said auxiliary heater;

wherein said cooling means comprises:

an exhaust vent, which is formed in the upper end of said heat insulating wall connecting said clearance;

a supply vent, which is formed in the lower end of said heat insulating wall connecting said clearance;

an air supply source, which is capable of supplying air for cooling from said supply vent to said clearance;

a pair of shutters, which are capable of opening and closing said exhaust vent and said supply vent, respectively; and

shutter moving means, which is capable of opening and closing said pair of shutters.

[Claim 13] The optical fiber drawing furnace according to Claim 11, characterized in that said cooling means comprises a cooling liquid channel, which is disposed so as to surround an auxiliary heater; and a cooling liquid supply source, which is capable of supplying cooling liquid to this cooling liquid channel.

[Claim 14] The optical fiber drawing furnace mentioned in any one of Claims 11-13, characterized by at least one temperature sensor, which detects the temperature of said preform holding cylinder; and

control means, which control said auxiliary heater and said cooling means, respectively, based on the detection signal from this temperature sensor.

[Claim 15] The optical fiber drawing furnace mentioned in any one of Claims 11-14, characterized in that sets of said auxiliary heater and said cooling means are provided in plural.

[Detailed Description of the Invention]

[0001]

[Related Field of the Invention]

The present invention relates to an optical fiber drawing method capable of suppressing diameter fluctuations to an optical fiber drawing furnace used therein.

[0002]

[Prior Arts]

Generally, optical fiber is drawn by softening with heat and elongating a rod-shaped optical fiber preform in an optical fiber drawing furnace. As a means of reducing the production costs of such optical fiber, the optical fiber preform is made in long lengths so that there are fewer replacement steps thereby realizing a continuous fiber drawing operation spanning hundreds of kilometers.

[0003]

In an optical fiber drawing furnace used for drawing an optical fiber preform into such optical fiber, as disclosed in, for example, Japanese Patent Application Laid-open No. Hei 9-2832, a preform holding cylinder that forms the upper chamber for holding the upper portion of the optical fiber preform is connected above a furnace core tube that is surrounded by a heater that heats the bottom end of the optical fiber preform to configure a semi-closed space that connects to the inside of the furnace core tube. An inert gas such as helium or nitrogen is then supplied to the inside of the upper chamber from the upper end of the preform holding cylinder; inside the upper chamber and inside the furnace core tube there connected, a non-oxidizing atmosphere is maintained; and optical fiber is drawn from the lower

end of the optical fiber preform while being softened with heat.

[0004]

With the optical fiber drawing furnace structured having the preform holding cylinder connected to the furnace core tube, as the optical fiber drawing operation progresses, the optical fiber preform becomes shorter so that the space that contains the optical fiber preform held within the upper chamber becomes progressively more empty. Because of this, in addition to it becoming easier for the inert gas located here to flow, as a result of the temperature difference with the inert gas located inside the furnace core tube growing larger, thereby leading to the development of convection phenomena in the inert gas between the inside of the furnace core tube and the upper end of the upper chamber.

[0005]

When such convection develops in the inert gas, the flow of the gas forming the atmosphere at the lower end of the optical fiber preform that is softened with heat also becomes unstable, fluctuations in the fiber diameter of the optical fiber drawn tend to become quite large, and it becomes difficult to obtain a certain desired quality in the finished product.

[0006]

As a result of this, in order to prevent the phenomena of inert gas convection between the inside of the furnace core tube and the upper end of the upper chamber, in Japanese Patent Application Laid-open No. Hei 9-2832, the aforementioned heat convection is prevented by heating the upper end of the upper chamber to a

temperature of hundreds of degrees Celsius using an annular auxiliary heater in order to stabilize the fiber diameter of the optical fiber to be formed.

[0007]

[Problems to be Solved by the Invention]

In the case where the length of the optical fiber preform is made even longer in order to make even fewer replacement steps during the optical fiber drawing operation, with the conventional optical fiber drawing furnace disclosed in Japanese Patent Application Laid-open No. 9-2832, the volume of empty space within the upper chamber is increased since it is necessary to lengthen the preform holding cylinder in which it is held. In the case where the area heated by the auxiliary heater is not increased against the lengthening of this preform holding cylinder, it becomes easier for convection in the gas supplied into the upper chamber to develop, whereby the fiber diameter of the optical fiber to be obtained becomes unstable. In other words, in the case where the preform holding cylinder is lengthened in accordance with the lengthening of the optical fiber preform, it is obvious that there develops a need for the area heated by the auxiliary heater to be increased in order to prevent heat convection in the inert gas between the inside of the furnace core tube and the upper end of the upper chamber.

[0008]

However, in the case where the area to be heated by the auxiliary heater is increased as the preform holding cylinder is lengthened, there is a danger that a large amount of radiant heat may

be emitted from the shoulder portion of the top of the optical fiber preform connected to a small-radius support rod to cause the portion of the preform holding cylinder facing the shoulder portion to be fused.

[0009]

In addition, as a result of the shoulder portion of the optical fiber preform being subjected to excessive heat accompanying this and becoming softened, this portion is pulled so as to be lengthened by the weight of the optical fiber preform itself; and since the fiber diameter of the optical fiber rapidly increases during the fiber drawing operation, there is a danger of inviting a situation where it becomes necessary to halt this fiber drawing operation.

[0010]

The objective of this invention is to provide a method of optical fiber drawing and a fiber drawing furnace, with which it is possible to continuously perform the fiber drawing of an optical fiber having a stabilized fiber diameter by preventing the heating of the shoulder portion of an optical fiber preform and the fusion of the top of a preform holding cylinder from occurring, even in the case where the area heated by the auxiliary heater is increased and the preform holding cylinder that is followed by the furnace core tube is lengthened in accordance with the lengthening of the optical fiber preform.

[0011]

[Means of Solving the Problems]

In an optical fiber drawing method in which an optical fiber preform is supplied from an upper chamber into a furnace core tube, and while heating the upper portion of said upper chamber, the lower

end of said optical fiber preform is softened with heat to allow optical fiber to be drawn; a first aspect of the present invention is characterized by comprising, in the case where the upper end of said optical fiber preform is positioned at a heating area of the upper portion of said upper chamber, a step of facilitating heat dissipation from said upper portion without heating the upper portion of said upper chamber.

[0012]

Here the heating area of the upper portion of the upper chamber is shown by the area surrounded by the auxiliary heater for heating such area.

[0013]

According to the present invention, in the case where the upper end of an optical fiber preform is positioned at the heating area of the upper portion of the upper chamber and the temperature of the preform holding cylinder structuring the upper chamber is within a predetermined range, it is possible to prevent the fusion of the upper portion of the preform holding cylinder that structures the upper chamber, and the softening of the upper end of the optical fiber preform due to excessive heat, without heating the upper portion of the upper chamber, through the facilitation of heat dissipation from said upper portion. In addition, in the case where the upper end of the optical fiber preform is not positioned at the heating area of the upper portion of the upper chamber, the upper portion of the upper chamber is heated in order to prevent heat convection between the inside of the furnace core tube and the upper end of the upper chamber.

[0014]

In an optical fiber drawing method in which an optical fiber preform is supplied from an upper chamber into a furnace core tube, and while heating the upper portion of said upper chamber, the lower end of said optical fiber preform is softened with heat to allow optical fiber to be drawn; a second aspect of the present invention is characterized by comprising, in the case where the upper end of said optical fiber preform is positioned at a heating are of the upper portion of said upper chamber, a step of facilitating heat dissipation without heating the portion of said upper chamber facing the upper end of said optical fiber preform.

[0015]

Here, the heating area of the upper portion of the upper chamber is shown by the area surrounded by the auxiliary heater for heating such area.

[0016]

According to the present invention, in the case where the upper end of an optical fiber preform is positioned at the heating area of the upper portion of the upper chamber and the temperature of the preform holding cylinder structuring the upper chamber is within a predetermined range, it is possible to prevent the fusion of the upper portion of the preform holding cylinder that structures the upper chamber, and the softening of the upper end of the optical fiber preform due to excessive heat through the facilitation of heat dissipation without heating the portion of the upper chamber facing the upper end of the optical fiber preform. In addition, in the case where the upper end of the optical fiber preform is not positioned at the heating area of

the upper portion of the upper chamber, the upper portion of the upper chamber is heated in order to prevent heat convection between the inside of the furnace core tube and the upper end of the upper chamber.

[0017]

In an optical fiber drawing furnace in which is provided a furnace core tube, which supplies an optical fiber preform; a main heater, which surrounds this furnace core tube; and a preform holding cylinder, which holds said optical fiber preform and is connected to the upper end of said furnace core tube; a third aspect of the present invention is characterized by comprising an auxiliary heater, which surrounds the upper portion of said preform holding cylinder; and a heater moving means, which moves the auxiliary heater between a heating position touching or near said preform holding cylinder and a heat dissipating position distant from said preform holding cylinder.

[0018]

According to the present invention, in the case where the upper end of an optical fiber preform is positioned at the portion of the upper chamber surrounded by the auxiliary heater through the preform holding cylinder and the temperature of the preform holding cylinder is within a predetermined range, by moving the auxiliary heater to the heat dissipating position away from the preform holding cylinder using the heater moving means and facilitating heat dissipation from the preform holding cylinder, it is possible to prevent the fusion of the upper portion of the preform holding cylinder structuring the upper chamber and the softening the upper end of the optical fiber preform due to excessive heat. In addition, in the case where the upper end of

the optical fiber preform is not positioned at the portion of the upper chamber surrounded by the auxiliary heater through the preform holding cylinder, in order to prevent heat convection between the inside of the furnace core tube and the upper end of the upper chamber, the auxiliary heater is moved to the heating position touching or near the preform holding cylinder using the heater moving means and the auxiliary heater is operated to heat the upper portion of the upper chamber.

[0019]

In an optical fiber drawing furnace in which is provided a furnace core tube, which supplies an optical fiber preform; a main heater, which surrounds this furnace core tube; and a preform holding cylinder, which holds said optical fiber preform and is connected to the upper end of said furnace core tube; a fourth aspect of the present invention is characterized by comprising an auxiliary heater, which surrounds the upper portion of said preform holding cylinder; and a cooling means, which cool the upper portion of said preform holding cylinder.

[0020]

According to the present invention, in the case where the upper end of an optical fiber preform is positioned at the portion of the upper chamber surrounded by the auxiliary heater through the preform holding cylinder, by operating a cooling means to cool the upper portion of the preform holding cylinder, it is possible to prevent the fusion of the upper portion of the preform holding cylinder structuring the upper chamber and the softening of the upper end of the optical fiber preform

due to excessive heat. In addition, in the case where the where the upper end of the optical fiber preform is not positioned at the portion of the upper chamber surrounded by the auxiliary heater, in order to prevent heat convection between the inside of the furnace core tube and the upper end of the upper chamber, the operation of the cooling means is halted and the auxiliary heater is operated to heat the upper portion of the preform holding cylinder.

[0021]

[Style for carrying out the present invention]

With the optical fiber drawing method according to the first or second aspect of the present invention, the step of facilitating heat radiation may include a step of moving the heat source for heating the top of the upper chamber, e.g. the auxiliary heater away from the top of the upper chamber; or may correspond to the use of a cooling fluid. In such cases, the cooling fluid may be air, and it is also effective being water.

[0022]

In addition, when facilitating heat radiation, it is preferable that the temperature of the preform holding cylinder forming the upper chamber be maintained between 400 and 700°C.

[0023]

With the optical fiber drawing apparatus according to the third aspect of the present invention, the auxiliary heater includes a heat generating body and a heat insulator surrounding this heat generating body; and the heater moving means may even move only the heat insulator to the heating position and the heat dissipating position.

[0024]

In addition, at least one temperature sensor, which detects the temperature of the preform holding cylinder within the upper chamber or that forms this upper chamber, and controlling means, which controls the movement of the auxiliary heater and heater moving means based on a detection signal from this temperature sensor, may be further provided.

[0025]

Moreover, an auxiliary heater or heater moving means may be provided in plural along the length of the preform holding cylinder.

[0026]

With an optical fiber drawing apparatus according to the fourth aspect of the present invention, a space may be formed between the top of the preform holding cylinder and the auxiliary heater together with further providing an annular thermal insulation wall so as to surround in an airtight manner the auxiliary heater; and a cooling means may include an exhaust vent, which is formed at the upper end of the thermal insulation wall and connected to the space; a supply vent, which is formed at the lower end of the thermal insulation wall and connected to the space; an air supply source, which is able to supply air for cooling to the space from the supply vent; a pair of shutters, which are capable of opening and closing the exhaust vent and the supply vent, respectively; and a shutter driving means, which is able to open and close the pair of shutters.

[0027]

Alternatively, the cooling means may include a cooling liquid

channel, which is disposed so as to surround the auxiliary heater; and a cooling liquid supply source, which is able to supply a cooling liquid to this cooling liquid channel.

[0028]

Moreover, at least one temperature sensor, which detects the temperature of the preform holding cylinder, and controlling means, which controls the respective operations of the auxiliary heater and the cooling means based on a detection signal according to this temperature sensor, may be provided.

[0029]

In addition, sets of an auxiliary heater and cooling means may be provided in plural.

[0030]

[Embodiments]

Embodiments of a fiber drawing furnace, which is capable of embodying a method of optical fiber drawing according to the present invention, is described in detail while referencing FIG. 1 to FIG. 7; however, the present invention is not limited to such embodiments and may correspond to further combinations thereof, and technology of other fields that include similar subjects.

[0031]

The cross-sectional structure of an optical fiber drawing furnace in the first embodiment of the present invention is shown in FIG. 1; the main components therein are shown enlarged in FIG. 2; and the cross-sectional structure thereof cut along the arrow III to III is shown in FIG. 3. More specifically, on the periphery of the cylindrical furnace

core tube 12, which is provided at the center of the stainless steel furnace 11 that is lined with a heat insulator not shown in the Figures, an annular carbon heater 15, which is for drawing optical fiber 14 by heat fusing the bottom end of optical fiber preform 13 that is supplied to the inside of this furnace core tube 12 and which is used as the main heater of the present convention, is provided concentric with furnace core tube 12. Optical fiber preform 13 passes through joint 17 and has its upper end connected to the bottom end of support rod 16; the upper end of this support rod 16 hangs down from a chuck that is not shown in the Figures so as to be sequentially fed into the inside of furnace core tube 12 in accordance with the fiber drawing of optical fiber 14.

[0032]

Seal sheet 19, which is formed at the center of aperture 18 through which optical fiber 14 passes, is attached to the lower end of the aforementioned furnace core tube 12.

[0033]

In addition, on the upper end of the aforementioned furnace core tube 12, extending from the top of furnace body 12 so that upper chamber 20 is formed on the inside, a plurality (in the example shown in the Figure, there are two) of preform holding cylinders 21 and 22, which are made of a heat-resistant composite metal such as Inconel, are connected in series to the upper end of furnace core tube 12. At the upper end of preform holding cylinder 21 on the upper stage side in this embodiment, there is provided a gas introduction port, which is not shown in the Figure, and which is made of a heat-resistant composite metal such as Inconel. A gas supply pipe, which is not shown in the

Figure, and which is connected to an inert gas supply source not shown in the Figure, is attached to this gas introduction port; the inert gas such as helium or nitrogen from this inert gas source passes through the gas introduction port from the gas supply pipe, and is supplied to the upper end of upper chamber 20 to maintain an inert gas atmosphere inside the furnace.

[0034]

A cooling jacket, which is not shown in the Figure and which is connected to a refrigerant circulatory supply device not shown in the Figure, is embedded into the aforementioned furnace body 11; by controlling the supply of the refrigerant into the cooling jacket from the refrigerant circulating supply device, both of the temperatures of carbon heater 15 and the atmosphere inside furnace core tube 12 are maintained at a predetermined temperature.

[0035]

Shuttering 24, which forms small-diameter opening 23 through which support rod 16 passes while maintaining a slidably connected state, is superimposed onto the upper end of preform holding cylinder 21 on the upper stage side so as to seal upper chamber 20 to be nearly airtight.

[0036]

Around preform holding cylinder 21 on the upper stage side, a plurality (in the example shown in the Figure, there are two stages) of auxiliary heaters 25 are disposed, each being annular; by heating preform holding cylinder 21, which is surrounded by these auxiliary heaters 25, to a temperature of 400°C or higher, and by preventing heat

convection between the top of upper chamber 20 and the inside of furnace core tube 12, the fiber diameter of optical fiber 14 drawn from optical fiber preform 13 can be stabilized. However, if the top of preform holding cylinder 21 surpasses 800°C, since, in addition to there being a danger of this preform holding cylinder 21 fusing, there develops a danger of shoulder portion 26 of optical fiber preform 13 softening due to excessive heat and this portion being pulled and lengthened due to the weight of optical fiber preform 13 itself, it is necessary for the top of preform holding cylinder 21 to maintain 800°C or lower, and in consideration of long term stability, preferably 700°C or lower.

[0037]

Auxiliary heaters 25 in this embodiment include iron-chrome-aluminum based heating wire 27 for heating the top of upper chamber 20, that is, the inside of preform holding cylinder 21 on the upper stage side in this embodiment; and heat insulator 28, which is made of ceramic fiber, for example, and surrounds heating wires 27 so as to hold it; connected to the heating wire 27 of each auxiliary heater 25 is control device 29, which controls the respective energization of said heating wires 27 to be on or off. Temperature sensor 30, which is, for example, a heating temperature thermometer for detecting the temperature of preform holding cylinder 21, is also connected to this control device 29, and the detected information from this temperature sensor 30 is output from control device 29. In this embodiment, a pair of temperature sensors 30 is provided for each respective auxiliary heater 25 on the respective surface of the outer

circumference of preform holding cylinder 21.

[0038]

Auxiliary heaters 25 in this embodiment are respectively shaped as semicircular arcs facing each other with preform holding cylinder 21 and temperature sensor 30 between, and in their entirety make a cylindrical shape. Heater moving device 33, the operation thereof controlled by control device 29, is connected to these auxiliary heaters 25; and through this heater moving device 33, auxiliary heaters 25 are switched between the heating position, which is shown in FIG. 3 with a chain double-dashed line, and the heat dissipating position, which is shown with a solid line.

[0039]

Preform holding cylinder 21 is able to maintain 700°C or lower by operating auxiliary heaters 25 at such a heating position. In addition, the heat dissipation effect can be heightened for preform holding cylinder 21 by stopping the energizing of such auxiliary heaters 25 at a heating position where the clearance between preform holding cylinder 21 and auxiliary heaters 25 is widened to be 4 to 5 cm.

[0040]

In this embodiment, the two-sectional structured auxiliary heater 25 is shifted towards each other between the heating position and the heat dissipating position; however, heating wires 27 and heat insulators 28 of each auxiliary heater 25 may be made separable, heating wires 27 be ensheathed in a heat-resistant composite metal through an insulating material and attached to the surface of the outer circumference of preform holding cylinder 21, and only the portions of

heat insulators 28 be shifted between the heating position and the heat dissipating position. In this case, heating wires 27 and heat insulators 28 are in a cohesive state at the heating position, and at the dissipating position there is formed a clearance for heat dissipation between heating wires 27 and heat insulators 28.

[0041]

In addition, in the embodiment mentioned above, auxiliary heaters 25 are made to be the semicircular arc-shaped cross-section of a cylinder divided into two sections; however, it is possible for these to be divided further into three or more sections along the circumference thereof. Alternatively, a portion along the length thereof may be made to have a cutout C-shaped cross-sectional structure, and subjected to elastic deformation to the heat dissipating position by widening the width of such cutout portion.

[0042]

A schematic structure of the second embodiment, which employs auxiliary heater 25 having such structure, is shown in FIG. 4, wherein components having the same function as the previous embodiment are marked with the same reference numerals thereto, and duplicate descriptions are omitted. More specifically, the auxiliary heater 25 in this embodiment has a C-shaped cross-sectional structure wherein a portion thereof is cutout along its length, and through the widening of the width of such cutout portion 31, elastic deformation from the shape shown with the chain double-dashed line to the shaped shown with the solid line in FIG. 4 is made possible. By auxiliary heater 25 having such elastic deformation, heater moving

device 33, which controls the operation of auxiliary heater 25 using control device 19, is provided to widen clearance 32 between preform 21 and auxiliary heater 25 to be 4 to 5 cm in order to heighten the heat dissipation effects for preform holding cylinder 21.

[0043]

In FIG. 4, auxiliary heater 25 is shifted in accordance with the elastic deformation between the heating position of heating wire 27 shown by the chain double-dashed line near preform holding cylinder 21 and the heat dissipation location of heating wire 27 shown by the solid line away from preform holding cylinder 21; as a result of this, the top of upper chamber 20 is able to maintain 700°C or less.

[0044]

It is noted here that temperature sensor 30 mentioned above is disposed along the cutout portion 31 of auxiliary heater 25.

[0045]

In this embodiment as well, heating wire 27 and heat insulator 28 may be made to be separate, heating wire 27 be ensheathed in a heat-resistant composite metal through an insulating material and attached to the surface of the outer circumference of preform holding cylinder 21, and heat insulator 28 be able to shift in accordance with such elastic deformation between the heating position and the heat dissipating position. In this case, heating wire 27 and heat insulator 28 are in a cohesive state at the heating position, and at the heat dissipating position there is formed a clearance for heat dissipation between heating wire 27 and heat insulator 28.

[0046]

In the first embodiment and the second embodiment mentioned above, at least heat insulator 28 is pulled away from preform holding cylinder 21 and clearance 32 facilitating heat dissipation from this preform holding cylinder 21 is formed; however, air for cooling may be forcibly supplied between preform holding cylinder 21 and auxiliary heater 25.

[0047]

The breakaway structure of the main components of a third embodiment of such an optical fiber drawing furnace according to the present invention is shown in FIG. 5, and the cross structure thereof cut along the arrow VI to VI is shown in FIG. 6; wherein components having the same function as the previous embodiments are marked with the same reference numerals thereto, and duplicate descriptions are omitted. More specifically, in this embodiment, auxiliary heater 25 does not include such above-mentioned cutout portion 31, but forms a complete ring-shape with an approximately 5 cm clearance 32 formed between it and preform holding cylinder 21. In addition, annular heat insulator 34 is placed between both of these respective upper and lower ends so as to seal clearance 32 between preform holding cylinder 21 and auxiliary heater 25. In this case, it is preferable that instead of heating wire 27 mentioned above, a nickel-chromium-based or iron-chromium-based heat generating body, which has superior heat resistance, be used.

[0048]

At the lower end of each auxiliary heater 25, supply tube 35 is connected to clearance 32 between preform holding cylinder 21 and

auxiliary heater 25 so that when heat dissipation is facilitated for preform holding cylinder 21, using the air supply source not shown in the Figure that is connected to this supply tube 35, air for cooling not shown in the Figure is blown into clearance 32 between preform holding cylinder 21 and auxiliary heater 25 at a maximum rate of 5 m^3 per minute. In addition, exhaust tube 36, which connects clearance 32 between preform holding cylinder 21 and auxiliary heater 25, is connected at the upper end of auxiliary heater 25 so as to release to the outside the air blown into clearance 32 between preform holding cylinder 21 and auxiliary heater 25.

[0049]

A pair of shutters 38, which are capable of being opened and closed simultaneously are attached to supply tube 35 and exhaust tube 36 mentioned above through shutter moving device 37, which controls the operation of control device 19 based on the detection signal from temperature sensor 30. More specifically, in order for preform holding cylinder 21 to be made 400°C or higher, auxiliary heater 25 is energized; and in order for this preform holding cylinder 21 be made 700°C or lower, the energization of auxiliary heater 25 is stopped and also shutters 38 are opened, so that by supplying a cooling air to clearance 32 between preform holding cylinder 21 and auxiliary heater 25 and releasing it from exhaust tube 36, the heat dissipation of preform holding cylinder 21 is facilitated.

[0050]

With this embodiment, through the supply of cooling air to clearance 32 between preform holding cylinder 21 and auxiliary heater

25 along a tangential line, a circulatory flow is formed within clearance 32 to heighten the heat dissipation effect; however, it is possible to obtain the same results by partitioning clearance 32 in a helical shape.

[0051]

With the embodiment mentioned above, through the supply of air to clearance 32 between preform holding cylinder 21 and auxiliary heater 25, the heat dissipation in preform holding cylinder 21 is facilitated; however, it is possible to facilitate heat dissipation even more effectively using water.

[0052]

A schematic structure of the fourth embodiment of such optical fiber drawing furnace according to the present invention is shown in FIG. 7; however components having the same function as the previous embodiments are marked with the same reference numerals thereto, and duplicate descriptions are omitted. More specifically, in this embodiment, heat-transfer plate 39 made of, for example, stainless steel, is attached to the outer circumference of auxiliary heater 25, and to this heat-transfer plate 39 there is cooling coil 40 wound into a spiral as well as heat insulator 41.

[0053]

One of the ends of cooling coil 40 is connected to water tank 44 through flow control valve 42 and water pump 43, and the other end of cooling coil 40 is connected to water tank 44 through condenser 45. Cooling water W is reserved in water tank 44, and air vent 46 is formed on the upper end portion thereof. In addition, between cooling coil 40 and flow control valve 42, air pump 48 is connected through switching

valve 47; the opening and closing of flow control valve 42, the operation of water pump 43, the opening and closing of switching valve 47, and the operation of air pump 48 are controlled using control device 19 not shown in the Figure (refer to the first embodiment through the third embodiment) based on a detection signal from temperature sensor 30 not shown in the Figure (refer to the first embodiment through the third embodiment).

[0054]

Accordingly, in the case where it is necessary to perform heat dissipation for preform holding cylinder 21 to bring it to 700°C or lower, switching valve 47 is closed; water pump 43 is activated while adjusting the degree of opening of flow control valve 42; a predetermined amount of cooling water W is made to flow to cooling coil 40 depending on the temperature of preform holding cylinder 21; and the heat dissipation of the upper portion of upper chamber 20 is facilitated. The vaporized cooling water W is subjected to condensation by condenser 45 and again returned to water tank 44. In this case, even if there is ebullition within water tank 44 due to the cooling water W returning from condenser 45, normal atmospheric pressure is maintained within water tank 44 using air vent 46.

[0055]

Conversely, in the case where it is necessary to heat preform holding cylinder 21 to 400°C or higher, as flow control valve 42 is closed while halting the operation of water pump 43, switching valve 47 is opened to allow air to blow in using air pump 48 draining the cooling water W disposed within cooling coil 40 toward the condenser 45 side.

[0056]

In this embodiment, heating wire 27 is ensheathed in heat insulator 28; however it is also possible to omit this heat insulator 28. In this case, it is preferable that both the upper and lower ends of the heat insulator be extended to connect to the outer circumference of preform holding cylinder 21 to seal heat insulator 28, similar to the case of the third embodiment.

[0057]

As a result of using an optical fiber drawing furnace of any of these first through fourth embodiments, the temperature of preform holding cylinder 21 is continuously adjusted to be between 400 and 700°C, to perform fiber drawing of long lengths of optical fiber preform 13, it is possible to manufacture optical fiber 16 to have little fluctuation in fiber diameter (125 μm $\pm$ 0.1 μm) spanning the entire length thereof.

[0058]

[Results of the Invention]

According to the present invention, in the case where the upper end of an optical fiber preform is positioned at the heating area of the upper portion of the upper chamber, since heat dissipation is facilitated without heating the upper portion of the upper chamber, even in the case where the heating area of the auxiliary heater is increased while the preform holding cylinder connected to the furnace core tube is lengthened in accordance with the lengthening of the optical fiber preform, it becomes possible to continuously perform a fiber drawing operation of an optical fiber having a stable fiber diameter by

preventing fusion of the upper portion of the preform holding cylinder and excessive heating of the shoulder portion of the optical fiber preform before they happen.

[0059]

In the case where the heat source, which is used for heating the upper portion of the upper chamber, is made so as to be moved away from the upper portion of the upper chamber in order to facilitate heat dissipation, the present invention can be easily realized by making only small modifications to conventional equipment without mounting special cooling means.

[0060]

In the case where a cooling fluid is used in order to facilitate heat dissipation, it is possible to control with greater ease and speed the adjustment of the temperature of the upper portion of the upper chamber; in particular, in the case where the cooling fluid is air, or alternatively water, that circulates around the periphery of the upper chamber, in addition to the usage cost of the cooling fluid kept down, it is possible to facilitate more effective heat dissipation.

[0061]

In particular, in the case where heat dissipation is facilitated so that the temperature of the preform holding cylinder is between 400 and 700°C, it is possible to perform the continuous fiber drawing operation of an optical fiber having a stable fiber diameter by reliably preventing the fusion of the upper portion of the preform holding cylinder that forms the upper chamber, and excessive heating of the shoulder portion of the optical fiber preform.

[0062]

According to the present invention, since there is provided an auxiliary heater, which surrounds the upper portion of the preform holding cylinder, and a heater moving means, which moves the auxiliary heater between a heating position touching or adjacent to the preform holding cylinder and a heat dissipating position separated from the preform holding cylinder, even in the case where the area to be heated by the auxiliary heater is increased while lengthening the preform holding cylinder, which is followed by the furnace core tube, in accordance with lengthening of the optical fiber preform, it becomes possible to continuously perform a fiber drawing operation of optical fiber having stable fiber diameter by preventing excessive heating of the shoulder portion of the optical fiber preform before it happens by halting the operation of the auxiliary heater and withdrawing to the heat dissipating position.

[0063]

In the case where the heater moving means moves only the heat insulator surrounding the heat generating body of the auxiliary heater to the heating position and heat dissipating position, it is possible to further simplify the mechanism and strength of the heater moving means.

[0064]

In addition, in the case where a temperature sensor, which detects the temperature of the upper part of the preform holding cylinder, and controlling means, which controls the operation of a heater moving means based on the detection signal of this temperature

sensor, are provided, it is possible to reliably determine the changeover timing from heating of the preform holding cylinder to heat dissipation thereof.

[0065]

Moreover, in the case where an auxiliary heater and heater moving means are provided in plural along the length of the preform holding cylinder, the delicate temperature adjustment of the preform holding cylinder is possible without regard to the lengthening of the optical fiber preform.

[0066]

According to the present invention, since an auxiliary heater, which surrounds the upper portion of the preform holding cylinder that forms the upper chamber, and a cooling means, which cools the upper portion of the preform holding cylinder, are provided, by performing more effective heat dissipation for the upper portion of the preform holding cylinder to reliably prevent fusion of the upper portion thereof and excessive heating of the shoulder portion of the optical fiber preform, it is possible to continuously perform fiber drawing of an optical fiber having a stabilized fiber diameter.

[0067]

Moreover, in the case where an air-tight, annular insulating wall surrounding the auxiliary heater is provided while forming a clearance between the upper portion of the preform holding cylinder and the auxiliary heater; and the cooling means includes an exhaust vent, which is formed in the upper end portion of the insulating wall connecting the clearance; a supply vent, which is formed at the lower

portion of the insulating wall connecting the clearance; an air supply source, which is capable of supplying air for cooling to the clearance from the supply vent; a pair of shutters, which are capable of opening and shutting the respective exhaust vent and supply vent; and a shutter moving means, which is capable of opening and closing the pair of shutters, it is possible to perform more effective heating of the preform holding cylinder and the heat dissipation thereof.

[0068]

In the same manner, in the case where the cooling means includes a channel for cooling fluid, which is configured so as to surround the auxiliary heater, and a cooling fluid supply source, which is capable of supplying cooling fluid to such channel for cooling fluid, it is possible to perform more effective heating of the upper portion of the upper chamber and the heat dissipation thereof.

[0069]

In addition, in the case where at least one temperature sensor, which detects the temperature of the preform holding cylinder, and control means, which controls the operation of the auxiliary heater and cooling means, respectively, based on the detection signal from such temperature sensor, are provided, it is possible to reliably determine the changeover timing from heating of the preform holding cylinder to heat dissipation thereof.

[Brief Description of Drawings]

[Fig. 1]

A conceptual diagram showing the schematic structure of a first embodiment of an optical fiber drawing furnace according to the

present invention

[Fig. 2]

A selective enlarged view of the main components in the embodiment shown in FIG. 1

[Fig. 3]

A cross-sectional view cut along arrow III to III in FIG. 2

[Fig. 4]

A cross-sectional view showing the schematic structure of a second embodiment of the present invention

[Fig. 5]

A conceptual diagram showing the schematic structure of a third embodiment of an optical fiber drawing furnace according to the present invention

[Fig. 6]

A cross-sectional view cut along arrow VI to VI in FIG. 5

[Fig. 7]

A conceptual diagram showing the schematic structure of a fourth embodiment of an optical fiber drawing furnace according to the present invention

[Explanation of Reference Numerals]

11 furnace body

12 furnace core tube

13 optical fiber preform

14 optical fiber

15 carbon heater

16 support rod

17	joint
18	opening
19	seal sheet
20	upper chamber
21,22	preform holding cylinder
23	opening
24	shuttering
25	auxiliary heater
26	shoulder portion
27	heating wire
28	heat insulator
29	control device
30	temperature sensor
31	cutout portion
32	clearance
33	heater moving device
34	heat insulator
35	supply tube
36	exhaust tube
37	shutter moving device
38	shutter
39	heat-transfer plate
40	cooling coil
41	heat insulator
42	flow control valve
43	water pump

44	water tank
45	condenser
46	air vent
47	switching valve
48	air pump
W	cooling water

DOCUMENT NAME Drawing
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Fig. 1
~~【図1】~~

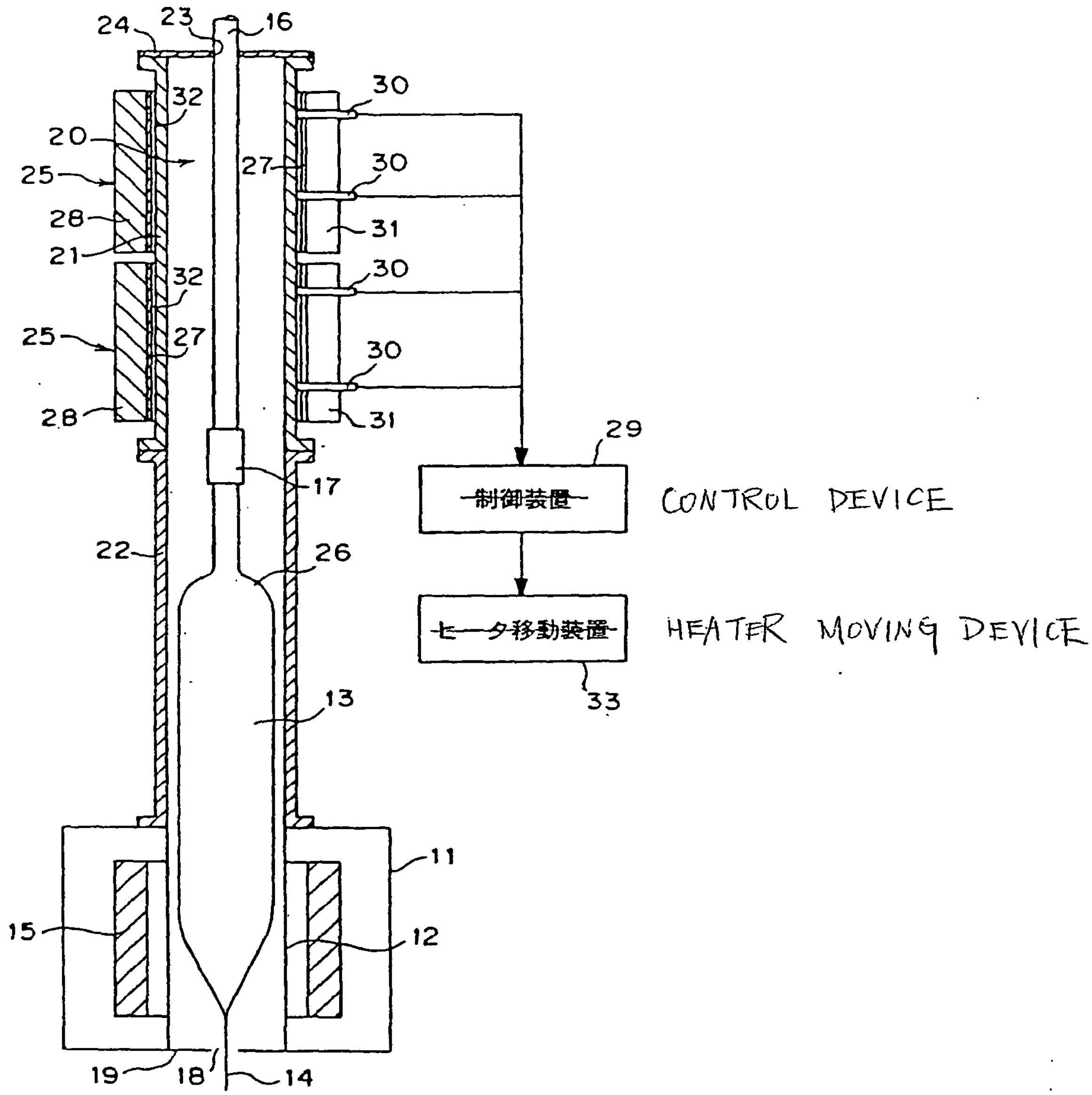

Fig. 2
【~~図2~~】

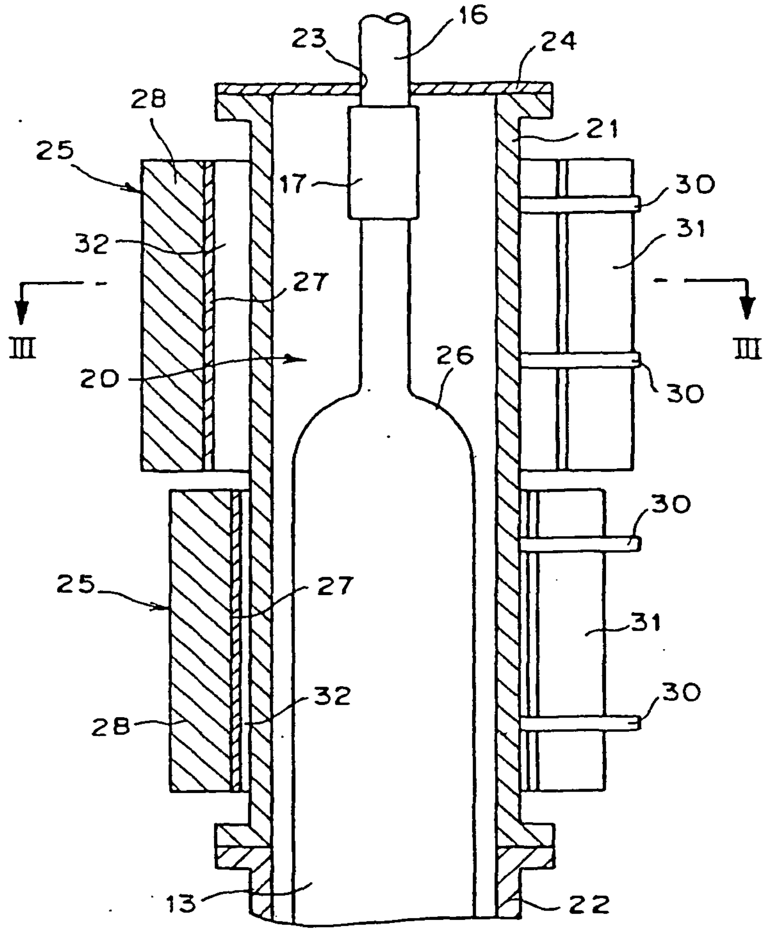
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Fig.3
~~【図3】~~

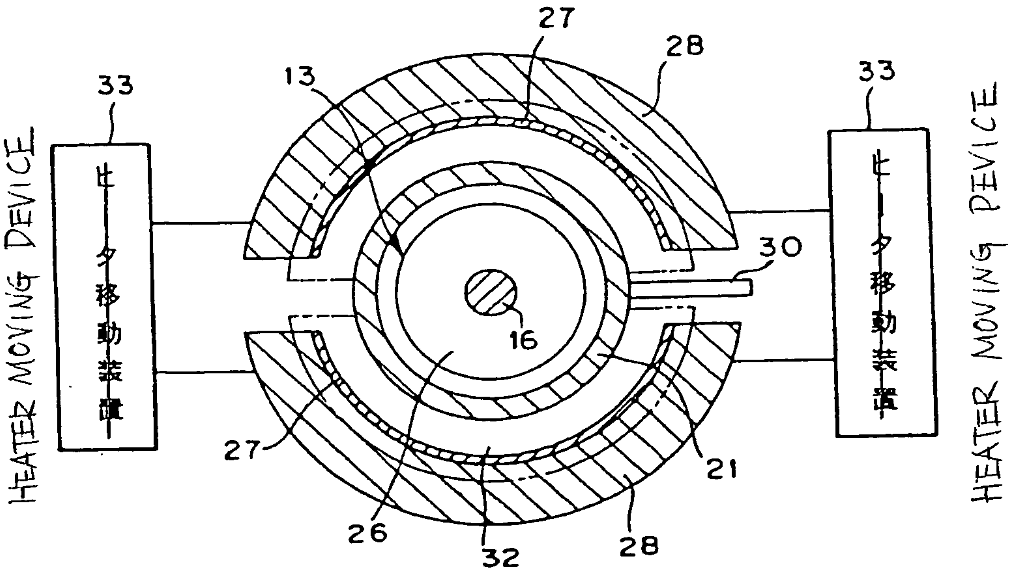

Fig.4
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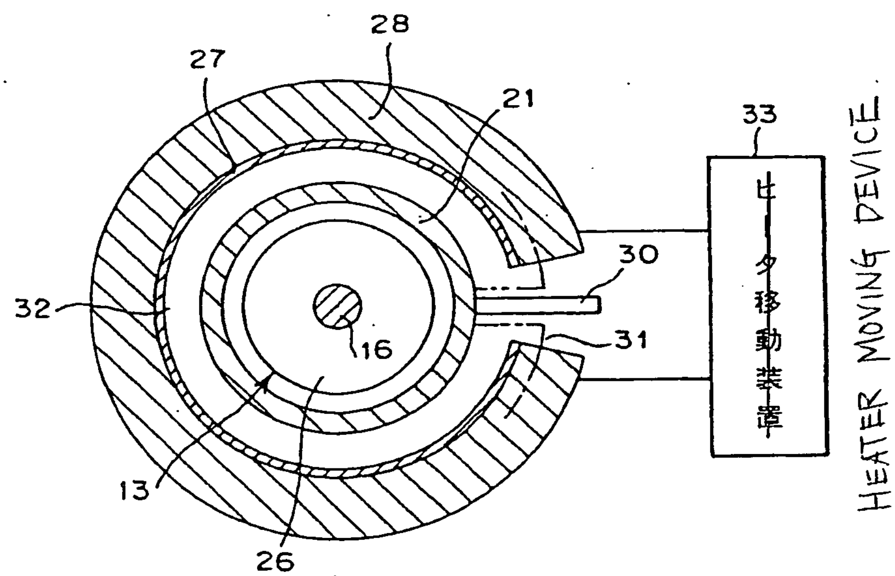
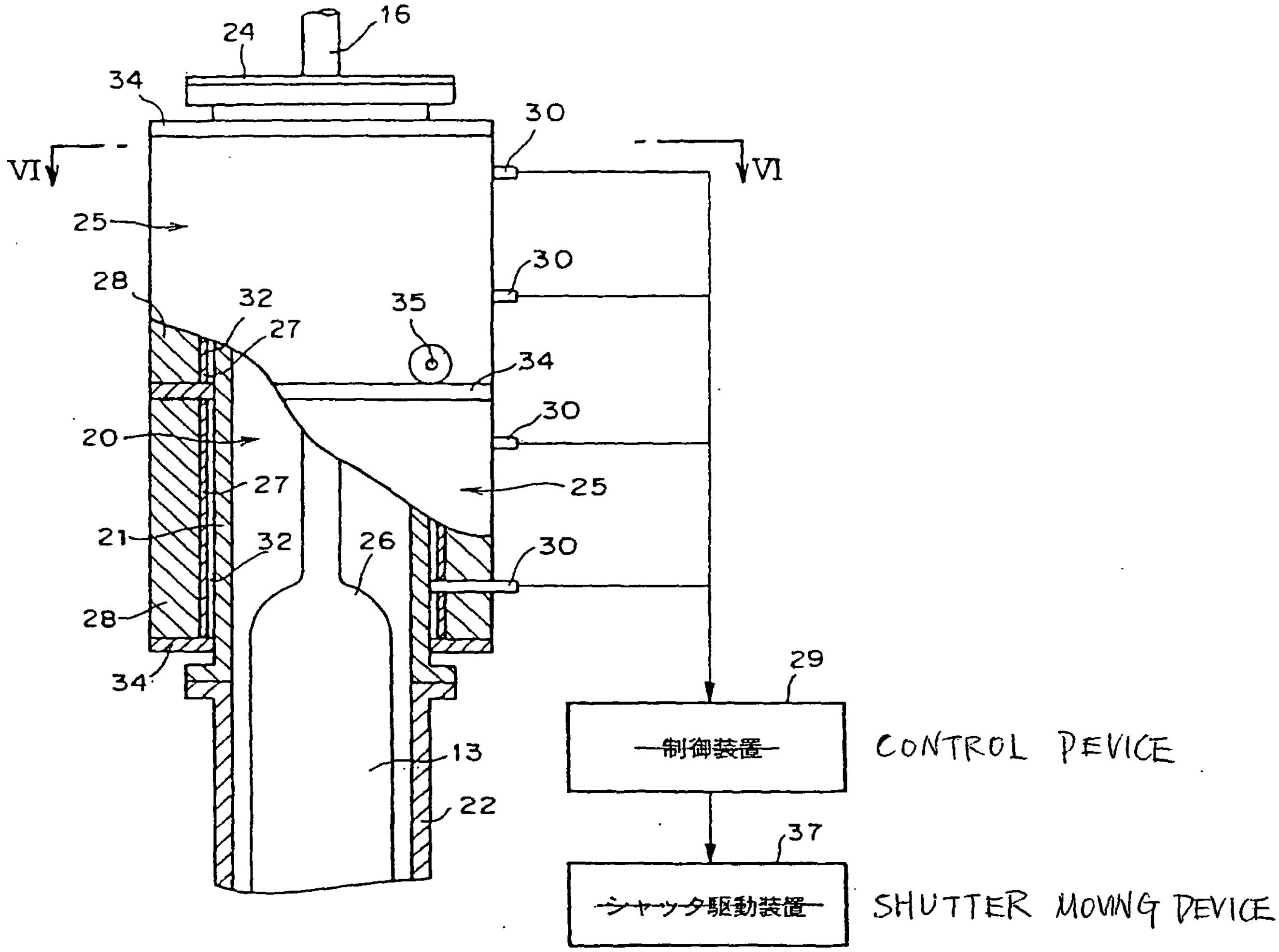


Fig.5
【~~図5~~】



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~~制御装置~~
CONTROL DEVICE
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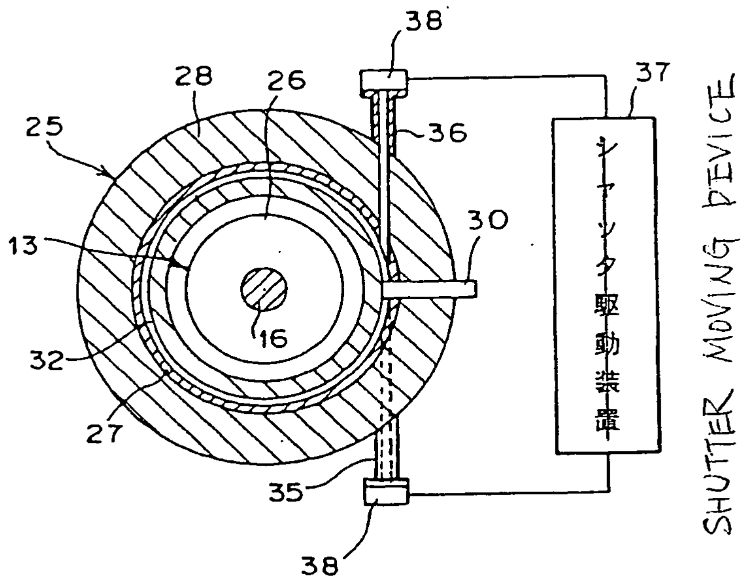
~~シャッタ駆動装置~~
SHUTTER MOVING DEVICE

Fig.6
~~【図 6】~~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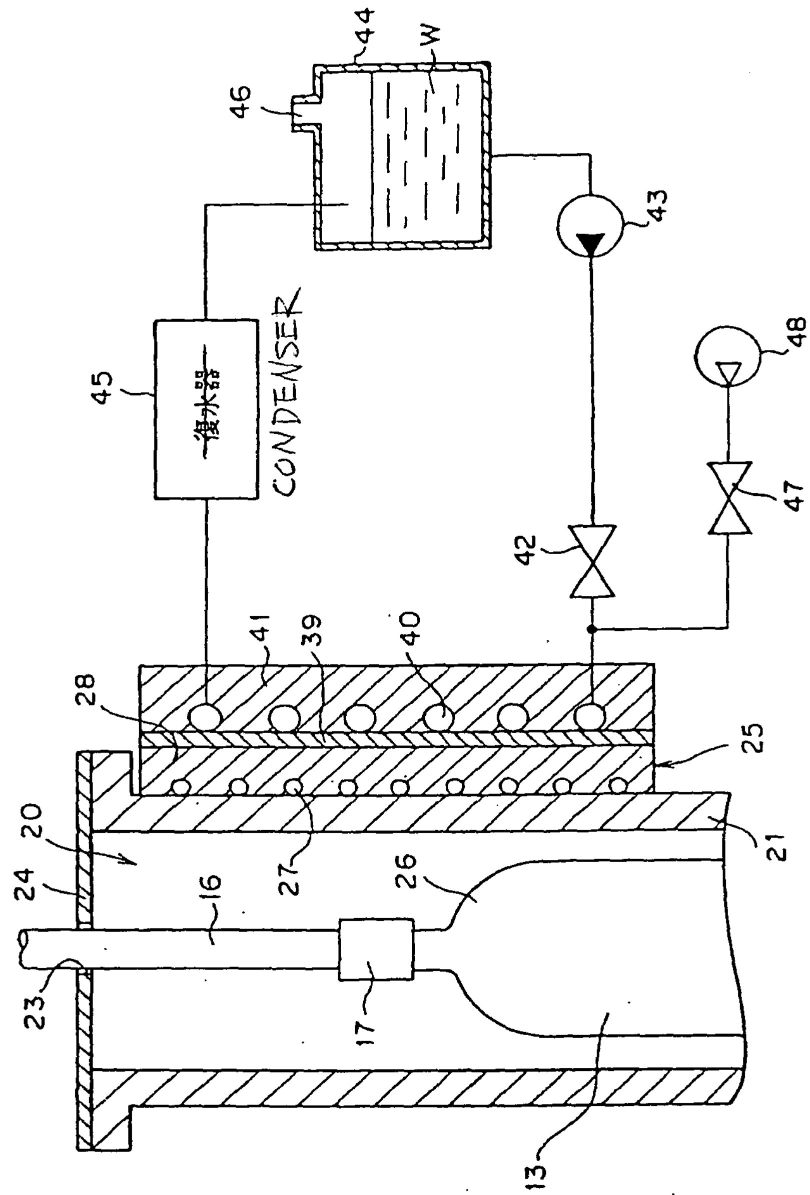
シャッタ駆動装置
SHUTTER MOVING DEVICE

Fig. 7
~~【図7】~~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~~復水器~~
CONDENSER
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[Type of Document] Abstract

[Abstract]

[Subject] In the case where a preform holding cylinder, which is followed by a furnace core tube, is lengthened in accordance with the lengthening of an optical fiber preform and the area to be heated by an auxiliary heater is increased, the upper portion of the preform holding cylinder fuses and the shoulder portion of the optical fiber preform is subjected to excessive heat making it difficult to perform fiber drawing of a stabilized optical fiber.

[Means for Solving] An optical fiber drawing furnace, which comprises furnace core tube 12 to which optical fiber preform 13 is supplied, carbon heater 15 surrounds this furnace core tube 12, and upper chamber 20, which is connected to the upper end of furnace core tube 12 to hold optical fiber preform 13, is made so as to comprise auxiliary heater 25, which surrounds preform holding cylinder 21, and heater moving device 33, which moves this auxiliary heater 25 between the heating position touching or near preform holding cylinder 21 and the heat dissipating position away from preform holding cylinder 21, and, in the case where the upper end of optical fiber preform 13 is positioned at the heating area of the upper portion of upper chamber 20, heat dissipation is facilitated without heating preform holding cylinder 21.

[Selected Drawing] FIG. 1